EXHIBITS

Greg Langdon, "Voice over DSL sounds promising", Network World, 08/02/99

NETWORKWORLD
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Voice over DSL sounds promising

By GREG LANGDON
Network World, 08/02/99

Digital subscriber line (DSL) service to date has been used for moving data over the Internet at high speeds through existing copper links. However, a new class of equipment will broaden DSL's usefulness by allowing the movement of voice and data simultaneously over a single copper link, without architectural changes to existing networks.

Diagram of how it works

The payoff: Smaller organizations will soon be able to buy integrated, richly featured voice/data services in a way previously available to only the largest firms.

All the major telephone companies have standardized on ATM as the Layer 2 DSL transport protocol. In DSL data applications, stand-alone or networked PCs connect to a DSL modem, bridge or router, which function as network endpoints and provide a high-speed interface to the DSL service. The DSL modem, bridge or router encapsulates the PCs' IP-based data into ATM and transmits the resulting cell flows as ATM over DSL to the carrier's central office. At the central office, ATM traffic from multiple DSL links is aggregated and multiplexed onto a common upstream link, and each cell flow is directed toward its destination by one or more ATM switches.

DSL links are ready-made for voice/ data integration. ATM is designed to simultaneously transmit diverse traffic types over a common net and does an exceptional job differentiating traffic into distinct classes of service. What's needed to enable integrated voice/data over DSL is equipment that supports voice over ATM at each end of the local loop. The types of equipment needed for customer premises and central offices are the next-generation integrated access device (NG-IAD) and voice gateway, respectively.

The NG-IAD eliminates the DSL modem, bridge or router for data communications by interfacing PCs or PC networks to the DSL service, encapsulating IP-based data into ATM for DSL transmission and handling functions such as routing and IP address management. At the same time, the NG-IAD provides the DSL interface for voice equipment such as telephones, fax machines, key systems and PBXs, and sends and receives voice over ATM on the same DSL line. Because ATM excels at simultaneous transmission of voice and data, the result is toll-quality telephone service with enhanced calling features intact, and continuous, high-speed Internet access or remote LAN access over a single twisted copper

pair.

At the carrier's central office, a voice gateway completes the picture for integrated voice/data over DSL. Encapsulated voice traffic received at the carrier's DSL Access Multiplexer (DSLAM) is sent to the voice gateway, where it is converted to conventional voice signals and sent to a Class 5 voice switch. Data received at the DSLAM is carried as packet or cell traffic to its destination, typically an ISP or corporate network, just as in current DSL service.

This service can be readily and seamlessly integrated into existing nets. The use of a NG-IAD at the customer premises ensures that the impact on the voice and data equipment is small. Also, a voice gateway converts voice traffic between voice over ATM and the traditional formats used in existing phone nets.

One of the primary benefits of integrated voice/data over DSL is the ability to purchase all voice and data services from a single provider while gaining very high-speed data communications. Any business of any size will be able to enjoy the simplicity of a single point of contact for customer service, billing, expansion of services and management.

Another benefit is NG-IADs can dynamically make under-used voice-traffic bandwidth available to data traffic.

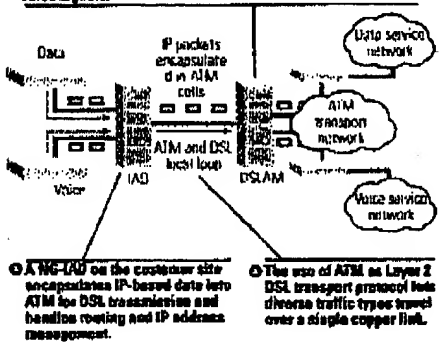
The market for NG-IADs has just begun to emerge as vendors explore the requirements for offering bundled services using DSL and a single copper pair. Technology demonstrations of NG-IAD and voice gateway products working together have provided proof of concept. Although there are limited equipment offerings that can provide this functionality today, a number of options will be available by next year and widespread adoption should follow.

HOW IT WORKS

Voice and data over DSL

Extending the data capabilities of DSL services to include voice will give organizations of all sizes access to benefits that have until now been enjoyed only by big companies.

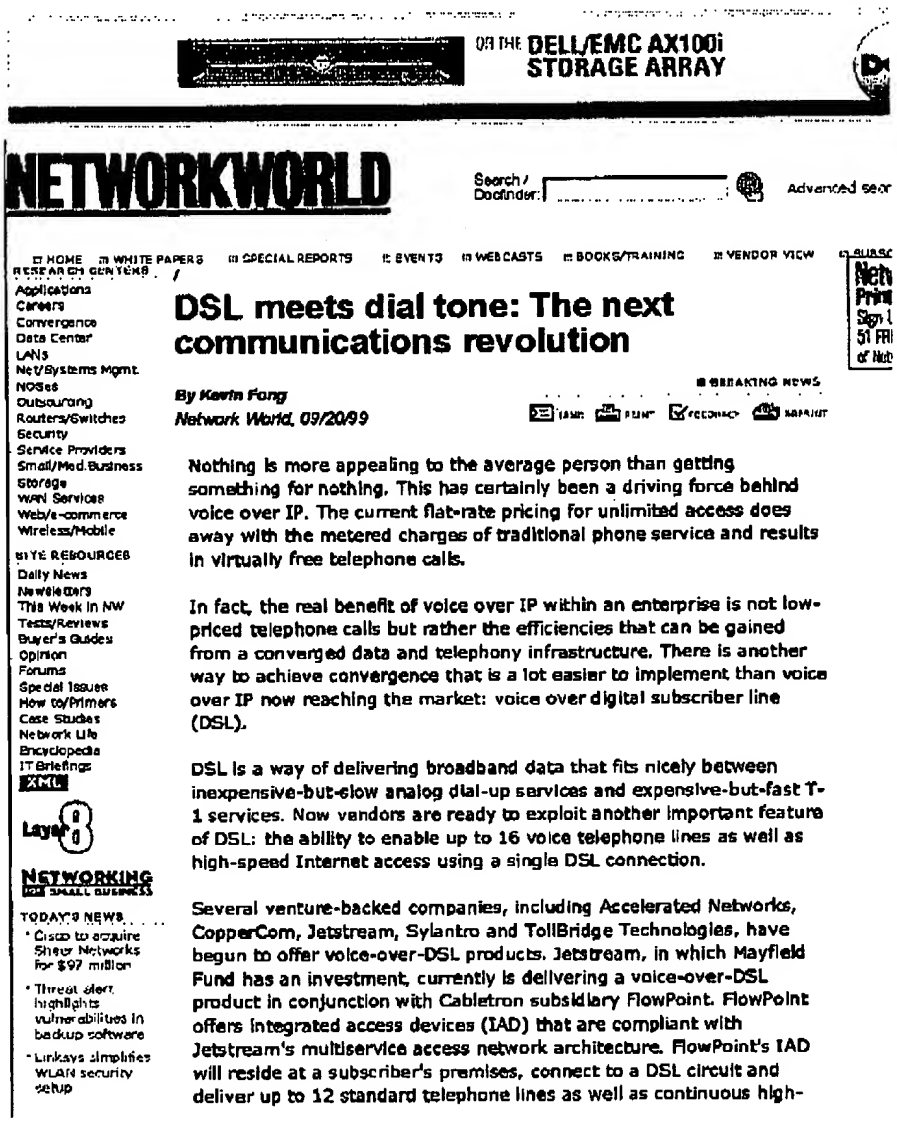
❶ At the carrier's central office, a DSLAM sends encapsulated voice traffic to voice gateway, which converts that traffic to conventional voice signals.



❷ A VG-IAD on the customer site encapsulates IP-based data into ATM for DSL transmission and handles routing and IP address management.

❸ The use of ATM as Layer 2 DSL transport protocol lets diverse traffic types travel over a single copper link.

Kevin Fong, "DSL meets dial tone: The next communications revolution", Network World, 09/20/99



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NETWORKING FOR SMALL BUSINESS

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DSL meets dial tone: The next communications revolution

By Kevin Fong
Network World, 09/20/99

BREAKING NEWS

Nothing is more appealing to the average person than getting something for nothing. This has certainly been a driving force behind voice over IP. The current flat-rate pricing for unlimited access does away with the metered charges of traditional phone service and results in virtually free telephone calls.

In fact, the real benefit of voice over IP within an enterprise is not low-priced telephone calls but rather the efficiencies that can be gained from a converged data and telephony infrastructure. There is another way to achieve convergence that is a lot easier to implement than voice over IP now reaching the market: voice over digital subscriber line (DSL).

DSL is a way of delivering broadband data that fits nicely between inexpensive-but-slow analog dial-up services and expensive-but-fast T-1 services. Now vendors are ready to exploit another important feature of DSL: the ability to enable up to 16 voice telephone lines as well as high-speed Internet access using a single DSL connection.

Several venture-backed companies, including Accelerated Networks, CopperCom, Jetstream, Sylantro and TollBridge Technologies, have begun to offer voice-over-DSL products. Jetstream, in which Mayfield Fund has an investment, currently is delivering a voice-over-DSL product in conjunction with Cabletron subsidiary FlowPoint. FlowPoint offers integrated access devices (IAD) that are compliant with Jetstream's multiservice access network architecture. FlowPoint's IAD will reside at a subscriber's premises, connect to a DSL circuit and deliver up to 12 standard telephone lines as well as continuous high-

- Networking start-ups' comeback continues
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speed Internet and remote LAN services over a single copper pair.

Start-ups are not the only ones interested in the voice-over-DSL market. Lucent recently announced a voice-over-DSL product that combines its PathStar portfolio of IP-based, multiservice central office products and MultiDSL access concentrators with Copper Mountain Networks' CopperEdge DSL concentrators and packet-based IADs. This product promises to deliver eight or more telephone lines and high-speed data services over a single unbundled local loop.

While voice over DSL is currently being aimed at households with multiple telephone lines and small to midsize businesses, it does have implications for large enterprises. Voice over DSL offers a highly cost-effective way to connect branch offices and teleworkers to the enterprise. In the case of branch offices, just four analog phone lines could yield enough carrying capacity for at least 24 simultaneous telephone calls and still leave plenty for high-speed Internet access.

For network managers who need to support a decentralized work force, voice over DSL looks to be the most cost-effective way to go.

RELATED LINKS

Fong is a general partner of Mayfield Fund, a venture capital firm in Menlo Park, Calif. He can be reached at kfong@mayfield.com.

Sandra L. Borthick, "IAD Roundup: Building The Bundles", Business Communications Review Access (supplement to Business Communications Review), pp. 4-13 (March 2000)

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Expanding Choices at the Network Edge

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IAD Roundup: Building The Bundles

from the March 2000 issue of BCR ACCESS, a supplement to Business Communications Review, pp. 4-13

by Sandra L. Berthick, technical editor of Business Communications Review.

Some time in the next year or so, you'll be offered a bundle. It might be a combination of voice and Internet access over DSL for your home, or PBX trunks plus frame relay for one of your branch offices, or high-speed LAN and multiple tieline connections between your customer service center and the shipping department across town.

You could get bundled service offers from practically any of today's integrated communications providers (ICPs), depending on the state of carrier competition where you live or work. And you'll hear essentially the same sales pitch, whether it's from the incumbent or competitive local exchange carriers (ILECs and CLECs), the interexchange carriers (IXCs), the DSL, cable or Internet service providers or their resellers: "Our bundles will cost you less, or they'll do more—or both—than the separate services that you are using today."

Of course you're skeptical, but go ahead and do the math. You may be surprised to find that some service bundles really will save you money, as much as 25 percent over what you're paying now, according to Sprint ION and AT&T INC spokesmen. Other bundles won't be cheaper—in fact, they may cost more than what you are paying today, but what you get could be startling: say, half-a-dozen more voice lines, or multiple megabits of additional data connectivity, for less than half what you'd pay if you ordered these services separately.

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The bundles aren't just about price-based competition for your voice and data traffic, or bonus bandwidth upgrades. They also include integrated access devices (IADs). You need the IAD for the same basic reason you need a modem, mux or a channel bank: to connect your voice and data equipment to the integrated access service. But most IADs also offer an intriguing mix of additional voice and data functions that go far beyond their single-purpose predecessors.

• Table 1: IAD Multiplexing Techniques, Configuration and Prices
• Table 2: IAD Voice Features
• Table 3: IAD Data Features

To explore this emerging product category, in November 1999 we sent questionnaires to as many vendors as we could identify who offered IADs that (*a.*) sit on the customer premises, (*b.*) collect customer voice and data traffic and (*c.*) multiplex it over one or more T1 (not DSL) lines. We asked them a series of detailed questions about their products, the results of which are shown in Tables 1–3, and we asked their opinions about the emerging market for integrated services.

We purposely, if arbitrarily, postponed the DSL-based IADs for a subsequent, separate review. We note, however, that several vendors of T1-based IADs are planning to support one or more of the DSL techniques (including Accelerated Networks, Adtran, Cisco, Integral Access, Memotec, Meriot, RAD, Telco Systems and Woodwind).

Amazing Amalgamations

Clearly, the equipment vendors who responded to our questionnaire have been trying to figure out every possible service the ICPs might want to include in their bundles, and how to support them all with either a single device or a family of related devices. The service providers only want to stock one or two platforms, according to Barry Zitting, product manager with Carrier Access Corp., "so they want the full gamut of voice and

data services as options, and they want upgradable platforms."

To an amazing extent, that's just what the vendors are delivering. As shown in Tables 1-3, these IADs are absolutely packed with multiple functions, and multiple choices for many of these functions. For example:

- Some support more than one of the latest statistically multiplexed packet handling techniques —PPP, frame relay and ATM—as well as legacy time division multiplexing (TDM) circuits (see Table 1). A few (Telco Systems and Vina Technologies) support them all!
- Many can connect and signal voice traffic in concert with any customer voice equipment—analog (e.g., FXS, FXO, E&M) and digital (e.g., CAS, CCS, Q.931, and Q.2931). And, as shown in Table 2, they provide a choice of voice compression algorithms (e.g., G.711, 723, 726, 729).
- Most can also interface to a variety of customer data equipment—not just Ethernet, but also Token Ring, SNA, IPX, even AppleTalk—and many offer a full complement of bridging, encapsulation and routing protocols (see Table 3).
- Many perform additional data network "edge" or "DMZ" functions, such as firewalling, network address translation (NAT) and dynamic host configuration protocol (DHCP) service (see Table 3).
- Most can handle fax and modem calls, and, as shown in Table 2 and Table 3, a few of the products offer VPN (Accelerated Networks, Meriot and Nortel) and PBX- or Centrex-type voice capabilities (Meriot and Vina).

Does it make sense to do all these things with a single device, or to put all your traffic over a single loop connection? Yes and no, according to analyst Marc Liggio, director of broadband research for Allied Business Intelligence. Liggio told *BCR ACCESS*, "Service providers want to be sure they create bundles that will attract as many customers as possible, but the more features they add, the more work it is for them."

The vendors' main technical difficulties and cost

components have to do with voice, Liggio says, because there are so many different compression algorithms and implementations, and vendors must pay royalties to use some of them. Nonetheless, he predicts healthy IAD sales—nearly $1.8 billion in 2004, up from just $9 million in 1999—especially for the ATM-based models, over the next five years.

Customer acceptance of bundled services and IADs will depend on price, compatibility and reliability, Liggio maintains, and these three factors can't be fully evaluated until the integrated services roll out in earnest. However, representatives of Accelerated Networks, Meriot and Vina are confident that the 7 million small and medium-sized businesses in the U.S. will embrace the new bundled offerings.

"These customers have historically been underserved by the ILECs," notes Kevin Walsh, VP marketing with Accelerated Networks. They can benefit just as well as bigger companies from advanced voice and data services, according to Vina's Sab Gosal, senior product manager, but they can't afford to buy all the piece parts and integrate them. "It has to be low-cost, easy-to-use and customizable," he adds.

Meriot's CEO and founder, Mike Centrella, agrees. "The [small and medium-sized businesses] will rapidly adopt these solutions because they meet their needs to simplify both the adoption and management of advanced communications services."

It also seems obvious that integrated service bundles could replace many of the separate voice and data connections used to link the branch offices of larger businesses to their headquarters and other centralized locations. Bigger organizations might also find work for the IADs themselves, using them to optimize traffic over point-to-point links in their private networks. Again,

Liggio's qualifiers—price, compatibility and reliability—will be key determinants, but it sure looks like some of these IADS could easily substitute for up to half a dozen older, single-purpose boxes that each cost much more than the multifunction IAD.

Shop and Compare

For example, consider a few of the simpler frame relay-based IADS, like FastComm's MetroLAN ($3,600), Nortel's Passport 4400 ($4,000), or Telco Systems' EdgeLink 300 ($3,550). These boxes can multiplex a few analog voice lines and a 10-Mbps Ethernet link onto a T1 circuit, performing FRAD, bandwidth management and quality of service (QOS) functions. Memotec's CX950 costs more ($6,348) but includes G.729 compression for its two analog voice lines, while Adtran's $9,600 Atlas 800Plus supports eight compressed voice (G.723.1) connections and includes an integral router.

You'll generally pay more for IADs with richer feature sets and the latest options, but few of the IADs can be compared exactly with one another and all are continuing to add more interfaces, protocols and other features. Comparisons are also difficult because suggested list prices are all over the place—from less than a thousand dollars for the Accelerated Networks AN-24 to tens of thousands for the maximum configurations of the Adtran, Nortel and Siemens products. (Note: several equipment vendors did not supply prices or configurations.)

For example, prices for somewhat comparable ATM-based IADs from Lucent, Mariposa, Nortel (5430), Siemens and Sonoma vary by thousands of dollars. Lucent's PSAX 15 starts at about $5,800 for multiplexing of up to 10 Ethernet and/or analog voice ports; Mariposa wants $6,395 for one 10-Mbps Ethernet, one v.35 and four analog voice ports; while Nortel's 5430 costs $15,770 for a dual 10/100 Ethernet and a single voice T1.

By comparison, Siemens' InterXpress IAD4700 costs about $7,700 for one 10/100 Ethernet, plus one up-to-8 Mbps V.35 interface and a single, circuit-emulated E1 (U.S.-variant T1 coming this year). Sonoma takes a different approach with its Integrator, which comes with four ATM T1 ports that can be used on the network or the customer side. Each can also be software defined for ATM user network interfaces (UNIs), inverse multiplexed ATM (IMA) or circuit emulation (CES). For $8,000 to $9,500, Sonoma also programs the Integrator to serve up to four 10/100 Ethernet ports, and two V.35 ports.

From there, it's only $500 more for Vina's $10,000 configuration of its Multiservice Xchange (MX) which offers more premise-side voice features, but only a single ATM T1 network connection. The MX serves a single 10-Mbps Ethernet and also provides complete voice services (CLASS and Centrex) to up to 48 analog telephones. Want more voice and data features? For $16,995, the Meriot MAGNUM ASP includes voice mail and automated attendant, an eight-port 10-Mbps Ethernet LAN switch and serves 28 telephones (16 analog and 12 digital). The price includes a single TDM T1, but Meriot will add an ATM T1 in the second quarter of this year.

At the high end of the IAD price spectrum are the high-capacity, maximum configurations offered by ADC and Adtran. ADC's TDM-based Opera Matrix Platform costs $46,230 and supports up to 36 serial data ports for data and 36 T1 (CSU or DSX) ports. The T1 ports can be used for digital voice (PBX) connections or as T1 network ports, or a mix. At $47,895, Adtran's frame-relay based ATLAS 800Plus handles four T1 connections to the frame relay network, plus 128 compressed voice (ADPCM) channels and includes an integral router.

With such a wide variety of IAD options—from transparent TDM muxes, to the latest hybrid packet devices—which are customers and carriers likely to

prefer? It's easy to project superficial match-ups (e.g., "you'll buy IADs based on what you already have deployed, ATM, frame relay or IP"), and to handicap the IAD vendors based solely on their basic technology assumptions ("Frame relay is transitional, IP isn't ready and ATM is complicated but here to stay").

But the networking market doesn't really lend itself to these simplistic assessments and blanket predictions. There are just too many interdependent, underlying variables to support any but the most obvious, "A=A" type statements about the emerging integrated services market.

Predictions, Perspectives And Perplexities

Nor can we really assume that service providers will stock only one or two IAD products to support their integrated service offerings. Old ILECs and IXCs operated that way for decades, but their centralized planning and glacial deployment didn't do much for previous integrated services (like ATM and ISDN).

Instead, it seems more likely that both old and new integrated communications providers (ICPs) will have to experiment for a while with the IADs and service bundles, for several reasons:

- Service providers don't really know which kinds of customers will prefer which combinations of services and features.
- There isn't a convenient match between the potential service requirements of customers and the access networks (central offices, fiber, remote terminals and copper) that currently connect them.
- There are too many good product and technology choices, all of which have some kind of track record and embedded base, to discount any of them.

For example, many IP and packet-switching proponents dismiss the time division multiplexing (TDM) and circuit-

orientation of the public switched telephone network (PSTN) as "old world networking." But these legacy technologies serve legions of existing customers, and they demonstrate the stability of well-known network interface and signaling protocol standards. As shown in Table 2, IAD products are already equipped with many of these interfaces and protocols (e.g., CAS, CCS, E&M, FXS, FXO, GR-303), and more are being added. No one questions the immediate need to support them, or their ongoing importance in the expected transition from circuit- and packet-based public networks.

While packet-based voice services have yet to see much success, both IP and frame relay data traffic continue to grow. Several IP protocols, including the Internet Web interface (HTTP) and transmission (TCP-IP) protocols, are practically ubiquitous today, while others are rapidly gaining ground. The point-to-point protocol (PPP) is enjoying a renaissance, while the newer Session Initiation Protocol (SIP) and Media Gateway Control Protocol (MGCP) are opening up new control-plane signaling options. As shown in Table 1, several IAD products use PPP variations to multiplex packet traffic (e.g., Cisco, Memotec, Telco Systems and Vina), while others, shown in Table 2, are planning to support MGCP and/or SIP (Fastcomm, Lucent, Merlot, Telco Systems).

Meanwhile, frame relay has produced a stable set of proven data interfaces and legacy data encapsulations, and ATM is hanging in as a transport multiplexing technique. In fact, ATM is getting some new transport job duties under the ATM Forum's AAL2 specification, which proponents tout as the best way yet to haul packetized voice and traditional signaling between the customer and ICP premises. Accelerated Networks, Merlot and Woodwind are among the vendors who support or plan to support AAL2.

Conclusion

That so many different IADs are available is a testament to the motivation of the vendors. That they are already equipped with such extensive sets of interfaces, protocols, features and functions—and are planning to add even more—shows the vendors' uncertainty, but also their willingness to put whatever it takes into these products to make them successful.

The ICPs will have their hands full for a while, figuring out which IADs and which services belong in which new service bundles, not to mention how to provision, manage and bill for them. And the IAD vendors will also be marketing through their distribution channels and resellers, as well as directly to networking customers.

Having more choices is always messier—it's more complex and confusing—but it also makes for more competition and lower prices. Perhaps in the case of these new IADs, it also signals the start of a networking era that lacks momentum behind a single technology. Maybe we are past the hypothetical, all-or-nothing wars. Instead of IP bigots and their stupid networks battling ATM bigots and their necessary circuits, while frame relay and TDM proponents try to stay "relevant," maybe we are entering a kind of hybrid networking world where practical uses will continue to be found for all of these.

This won't be as dramatic as having one technology "win," at the expense of the others, and it won't achieve that efficiently engineered, single-network nirvana—but it will make better sense and provide more choices.

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From IAD Roundup: Building The Bundles, BCR ACCESS, March 2000

TABLE 1: IAD Multiplexing Techniques, Configurations and Prices

Company	Product/ Ship Date	Mux Technique	Bandwidth Management, QOS and priorities	Minimum Configuration and Suggested List Price	Maximum Configuration and Suggested List Price
Accelerated Networks	AN-24, AN-28, AN-30/ current	ATM	ATM traffic priorization	4 analog voice ports, 10Mb Ethernet or V.35, CSU over ATM T1 $895	24 digital voice, one 10/ 100 Ethernet and 2 V.35, CSU over ATM T1 $3,695
ADC	Opera Service Matrix Platform/ Jan '98	TDM	TDM	24 analog voice ports, 3 V.35, CSU over 2 TDM T1 $15,700	36 v.35 and 36 T1 (station or trunk) ports $46,230
Adtran, Inc.	Atlas 800Plus/ Oct '98	TDM, Frame Relay	TDM and, with Frame Relay, user configurable priorities	8 G.723.1 voice, one 10Mb Ethernet over Frame Relay T1, built-in router & CSU $9,600	128 G.723.1 voice, one 10Mb Ethernet, 4 Frame Relay T1s, built-in router & CSU $47,895
Carrier Access Corp.	Cactus.lite/ Dec '99	TDM, ATM IMA in 2Q00	TDM and, in 2000, ATM with outbound policing	Cactus.lite Base only (chassis, dual T1 TDM controller and power supply) $1,990	Base plus six 8-port FXS cards $6,760
Cisco Systems	2600/ since Apr. '98	ATM, TDM, PPP, Cisco Express Forwarding	Multiple priority and queuing techniques	One 10-Mb Ethernet, one 115.2Kb async and two T1 (1 PBX, 1 WAN uplink), CSU/ DSU $4,495	48 compressed (G.729A) VOIP ports, one 10Mb Ethernet, one 115.2Kb async over T1 uplink, DSU $15,795
Cisco Systems	36xx/ since Nov. '96	ATM and IMA, TDM, Cisco Express Forwarding	Multiple priority and queuing techniques	ND	ND
Cisco Systems	3810/ since Feb. '98	ATM and IMA, TDM, PPP	Multiple priority and queuing techniques	1 analog voice interface, one 115.2Kb async (voice over Frame Relay or HDLC), one 10-Mb	24 digital voice (ATM) channels, one 115.2Kb async, one 10BaseT Ethernet, 2 serial

TABLE 1: IAD Multiplexing Techniques, Configurations and Prices

				Ethernet, 2 serial interfaces (up to 2 Mb each), one data, one WAN uplink, no CSU $3,895 ATM uplink, CSU/ DSU, BRI back-up, RS366 $10,480	interfaces (up to 2 Mbps each) over T1/ E1
Fastcomm Communications	MetroLAN VOFrame Relay/ VOIP/ current	Frame Relay	Fine-grained, CIR-sensitive control via vendor's Maximum Priority Queuing feature	3 analog voice ports, one 10Mb Ethernet and 2 RS-232 over Frame Relay V.35, $3,600	3 analog voice ports, one 10Mb Ethernet, and 2 RS-232 over Frame Relay T1 with CSU $3,900
Fastcomm Communications	GlobalStack-EX/ current	Frame Relay		Chassis with 6 compressed voice ports, one PBX T1 interface, one 10Mb Ethernet over one Frame Relay T1 $7,480	Chassis with 9 compressed voice ports, one 10Mb Ethernet, 2 V.35 over Frame Relay E1 $12,080
Integral Access	OUTburst-SB-223A, 1Q00	MPLS	Per-LSP queuing (MPLS), 3 traffic priorities: voice, committed rate data and best rate data	12 analog voice ports, one 10/ 100 Mb Ethernet, CSU over T1, E1 or SDSL. $2,000	24 analog voice ports, one 10/ 100Mb Ethernet and one V.35 CSU. Price ND
Lucent Technologies	PSAX product family/ since 4Q97	ATM, IMA	ATM TM 4.0	PSAX 15 is one T1/ E1 ATM uplink with up to 10 Ethernet and T1/ E1 ports & CSU. Starts at $5,800	PSAX 600 can include redundant common logic and power and handle 57 I/ O ports. Price not disclosed
Mariposa Technology, Inc.	ATX family/ current	ATM	ATM traffic management	2-slot unit with single T1 uplink, 4 ports analog voice, one 10Mb Ethernet and one V.35 & CSU $7,095	3 T1/ E1 compressed voice, one each 100Mb Ethernet, T1/ E1 video, T1/ E1 Frame Relay over ATM OC3 $22,895

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TABLE 1: IAD Multiplexing Techniques, Configurations and Prices

Memotec Communications	CX950/ Apr '99	PPP-ML over Frame Relay, ATM (option)	Programmable priority, buffer and queuing mechanism	2 analog voice, one 10MB Ethernet, one V.35. PPP-ML over Frame Relay $6,348	30 compressed voice (G.729) ports, one 10Mb Ethernet, one V.35, PPP-ML over Frame Relay $15,640
Merlot Communications	Magnum ASP/ 11-99/ Nov '99	TDM, ATM in 1H00	TDM & vendor's Deterministic Ethernet (internal traffic only) ATM 1H00	Chassis with voice processor, 16 ports analog voice, 8 ports analog trunks, access router, CSU and firewall over T1 $7,495	Chassis with voice processor, 16 analog and 24 digital voice ports, 8-port 10Mb Ethernet switch, access router, CSU, firewall, 2 T1 $16,995
Nortel Networks	Passport 4400 family/ since '97	Frame Relay	Various priority queuing mechanisms & vendor's Frame RelayF 11 & 12	Base unit with a single analog port, one10Mb Ethernet, over V.35 Frame Relay WAN interface $4,000 8-port data module (station or trunk, including Frame Relay WAN access) $14,000	Base unit with one digital E1 interface and one 2-port analog voice interface (station or trunk), one 8-port data module (station or trunk), including Frame Relay WAN access $14,000
Nortel Networks	Passport 5430/ Feb '00	TDM, ATM	Static packet filters (dynamic with separate policy filter), up to 8 queue specs, ATM VCs	Chassis with two 10/ 100 Ethernet ports, one T1 CAS, trunk, CSU and ATM T1 uplink $15,770	Chassis with two power supplies, two 10/ 100 Mb Ethernet ports, 3 T1 CAS trunks, CSU, ATM T1 and 3 serial links $28,745
Premisys Communications, Inc.	IMACS family,	TDM	TDM		
Premisys Communications, Inc.	StreamLine/ current,	TDM	TDM		
Premisys Communications, Inc.	SlimLine/ current	TDM	TDM		
RAD Data Communications	FCD-IP/ current	TDM	TDM	T1 voice, one 10Mb Ethernet	One T1 voice port or 4 analog

TABLE 1: IAD Multiplexing Techniques, Configurations and Prices

				LAN,CSU over T1 uplink starts at $1,395	voice ports, two 10Mb Ethernet, plus one Nx64 data or backup port, CSU over T1 uplink. Price ND
Siemens Information and Communications Networks	InterXpress IAD 4700/ current	ATM	ATM traffic management	1 E1 CBR, 1 Frame Relay, one 10/ 100Mb Ethernet LAN, CSU over ATM (E1) uplink, 15,000DM	1 E1 CBR, 2 compressed (choice) E1, one 10/ 100Mb Ethernet LAN over STM-1 (155Mb) ATM uplink, 26,000DM
Sonoma Systems	Access/ current	ATM	ATM traffic management	4 T1 CES voice ports, and four 10/ 100 Ethernet LAN ports, CSU over ATM DS3/ E3 uplink $14,195	One T1 CES voice, one 10/ 100Mb Ethernet, CSU over ATM OC3c/ STM-1 uplink $15,195
Sonoma Systems	Integrator/ current	ATM	ATM traffic management uplinks, $8,000	One T1 CES voice, one 10/ 100 Ethernet CSU up to 4 T1/ E1 uplinks $8,000	One T1 CES voice, one 10/ 100 Ethernet, CSU over ATM IMA T1/ E1 uplinks $9,500
Telco Systems	EdgeLink 300 T1/ E1/ Dec '98	TDM, PPP over Frame Relay (ATM in 4Q00)	TDM, user-assigned priority queing	4 FXS voice ports and one 10Mb Ethernet, CSU over Single TDM T1 uplink $3,550	32 FXS voice ports, one 10Mb Ethernet, one V.35 and integral IP router & CSU over 2 TDM T1 uplinks $5,675
Vina Technologies	Multiservice Xchange (MX)/ YE99	TDM, ATM, PPP, Frame Relay	TDM ATM traffic management	4 analog voice, one 10Mb Ethernet, router & CSU over T1 $4,000	48 analog voice, one 10Mb Ethernet, router, CSU, Centrex, over ATM T1 $10,000
Woodwind Communications	ClariNet Service Intelligent Network Edge Gateway/ Feb. '00	TDM, ATM, Frame Relay	Task and queuing priorities, bandwidth allocation	One 4-port FXS and one 10-Mb Ethernet, CSU, over T1 $2,000	Three 4-port FXS and one 10-Mb Ethernet, CSU, over two T1s $4,000

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TABLE 2 IAD Voice Features

from IAD Roundup: Building The Bundles, BCR ACCESS, March 2000

TABLE 2: IAD Voice Features

Company	Product/ Ship Date	Packetization & Compression	Current Signaling Protocols	Signaling Features Planned For 2000	Other Voice Features
Accelerated Networks	AN-24, AN-28, AN-30/ current	AAL2, G.726	CAS, GR-303	CCS	CN, EC (in hardware), SS, TD, VAD
ADC	Opera Service Matrix Platform/ Jan '98	32k and 16k ADPCM	CAS, CCS	None	Loop & ground start, ring voltage, loop power, adjustable gain, far end ring tone, dial tone
Adtran, Inc.	Atlas 800Plus/ Oct '98	G.723.1	CAS, CCS	Q.SIG	EC, SS, TD, VAD
Carrier Access Corp.	Cactus.lite/ Dec '99	32k and 16k ADPCM	CAS	None	CN, EC, SS, TD, VAD
Cisco Systems	2600/ since Apr '98	G.711,723.1,726, 728, 729(A,B)	CAS, loop start, ground start, E&M, immediate start & delay start, Q.931 H.323v2	CCS, Q.SIG	CN, EC, SS, TD, VAD, IVR, user auth, adaptive jitter buffer, RTP header compression
Cisco Systems	36xx/ since Nov '96	G.711,723.1,726, 728,729 (A,B)	CAS, loop start, ground start, E&M, immed start & delay start, Q.931 H.323v2	CCS, Q.SIG	CN, EC, SS, TD, VAD, IVR, user auth, adaptive jitter buffer, RTP header compression
Cisco Systems	3810/ since Feb '98	G.711,723.1,726, 729(A, B)	CAS, loop start, ground start, E&M, immed start & delay start, transparent-CCS and Q.SIG, PRI	ND	CN, EC, SS, TD, VAD, IVR, user auth, adaptive jitter buffer, RTP header compression
Eastcomm Communications	MetroLAN and	G.723.1, 726, 727, 729 and	CAS, CCS, D4, E&M,	H.323, MGCP, SIP,	CN, EC, SS, TD, VAD, net delay and

TABLE 2 IAD Voice Features

	GlobalStack-EX/ current	729A	Q.SIG	R2 and R2 modified	jitter compensation, variable voice info framing, CDR, country-specific audible signaling
IntegralAccess	OUTburst-SB-223A 1Q00	G.711	CAS, CCS, PRI	None	CN, EC, SS, VAD, fast busy (planned: TD, tone gen and MGCP gateway functions)
Lucent Technologies	PSAX product family/ since 4Q97	G.723.1, 726, 727,729A	CAS, CCS	FXS & FXO loop start, FXS & FXO loop start, Q.SIG, PRI, IPDC/ MGCP	CN, EC, SS, VAD, bad frame interpolation
Mariposa Technology Inc.	ATX family/ current	G.729A on AAL5 (planned: AAL2, PCM, 32/ 16k ADPCM)	CAS, PRI, Q.SIG, Ericsson & Tadiran PBX	R1 & R2 CAS, BRI	CN, EC, SS, TD, VAD
Memotec Communications	CX950/ Apr '99	Proprietary 5.8/ 8k ACELP II (planned: G.711, 726, 729A)	CAS, CCS, BRI, PRI, Q.SIG, MFC-R2	Q.SIG GF, China Signaling No.1	CN, EC, SS, TD, VAD, DTMF error correction
Merlot Communications	Magnum ASP/ Nov '99	No (ADPCM planned)	CAS	CCS, SIP, MGCP and H.323	Tone detection and generation (EC and SS planned)
Nortel Networks	Passport 4400 family/ since '97	G.729	FXS & FXO loop start, E&M and digital wink start, CAS,CCS, Q.SIG, switchhook flash and hoot & holler	None	CN, EC, TD, VAD
Nortel Networks	Passport 5430/ Feb '00	G.729	CAS	Q.SIG	CN, EC, SS, TD, VAD
Premisys Communications	IMACS family/ current	ADPCM, ACELP	CAS, CCS, Q.SIG	V.5	EC, SS, TD
Premisys Communications	StreamLine/ current	No	CAS, CCS	ND	None
Premisys	SlimLine/	No	CAS	ND	None

TABLE 2 IAD Voice Features

Communications	current				
RAD Data Communications	FCD-IP/ current	No	CAS, CCS	PRI, Q.SIG	ND
Siemens Info & Comm Networks, Inc.	InterXpress IAD 4700/ current	FRF.11, G.723.1B and G.729A over ATM	CAS	CCS, Q.SIG, BRI, and ATM UNI 3.1 SVC for Q.SIG and DSS1	CN, EC, SS, TD, VAD
Sonoma Systems	Access & Integrator/ current	No	CAS, Q.2931	Q.931, Q.SIG	(planned: CN, SS, TD, VAD, DTMF capture & playout, progress tone detect & gen, ring gen)
Telco Systems	EdgeLink 300 T1/ E1/ Dec '98	G.723.1A, 726, 729AB, T30	For FXS, FXO & CAS: loop start, ground start and more	Q.SIG, MGCP, H.323	CN, EC, SS, TD, VAD
Vina Technologies	Multiservice Xchange (MX)/ YE '99	G.723, 726, 729	Flexible CAS, loop, ground, E&M, R2, V5.1, ATM UNI 4.0, Q.2931	PRI & BRI (Q.931/ 921)	EC, SS, TD, VAD
Woodwind Communications	ClariNet Service Intelligent Network Edge Gateway/ Feb '00	G.723.1, 726,729A & Jetstream proprietary AAL2	Q.931, Jetstream proprietary	CAS, CopperCom proprietary and Tollbridge proprietary	CN, EC, SS, TD, VAD, local call routing, local dial tone

TABLE 3 IAD Data Features

From IAD Roundup: Building The Bundles, BCR ACCESS, March 2000

TABLE 3: IAD Data Features

Company	Product/ Ship Date	Routing Protocols	Other Data Features	Fax and Modem Support
Accelerated Networks	AN-24, AN-28, AN-30/ current	Static, RIP1, RIP2, RFC 1483, FRF 5 & 8	DHCP, NAT, and VPN	CES AAL1
ADC	Opera Service Matrix Platform/ Jan '98	No	DS0 Inverse mux	TDM
Adtran, Inc.	Atlas 800Plus/ Oct '98	RIP 1, RIP 2 (OSPF planned)	DHCP, packet filter	via FR
Carrier Access Corp.	Cactus.lite/ Dec '99	Static, OSPF, RIP1, RIP2, FR, L2bridge	DHCP and NAT, packet filter	full rate, uncompressed
Cisco Systems	2600/ since Apr '98	Static, RIP 1&2, OSPF, BGP, BGP4, MPLS, IS-IS, more	Firewall, NAT, VPN (L2F, L2TP, IPSec), dial access (ISDN&V.34)	via fax relay and G.711 (for modem calls)
Cisco Systems	36xx/ since Nov '96	Static, RIP 1&2, OSPF, BGP, BGP4, MPLS, IS-IS, more	Firewall, NAT, VPN (L2F, L2TP, IPSec)	via fax relay and G.711 (for modem calls)
Cisco Systems	3810/ since Feb '98	Static, RIP 1&2, OSPF, BGP, BGP4, MPLS, IS-IS, more	Firewall, NAT, VPN (L2F, L2TP, IPSec)	via fax relay and modem detection
Fastcom Communications	MetroLAN and GlobalStack-EX/ current	Static, RIP 1, RIP2	Static & dynamic NAT, BootP, DHCP relay, IP packet filtering and prioritization	DSP compressed
Integral Access	OUTburst-SB-223A 1Q00	Static	DHCP, firewall, NAT, VPN	64kbps clear channel
Lucent Technologies/	PSAX product family since 4Q97	Static, RFC 1483, RFC 1577	BootP, DHCP relay (planned: DHCP, NAT and VPN)	3 user-selectable modes
Mariposa Technology Inc.	ATX family/ current	Static, RIP2 (OSPF planned)	VPN (via ATM PVCs, SPVCs, SVCs) firewall, NAT planned: DHCP	Terminate, encap in AAL 5 & remodulate
Memotec Communications	CX950/ Apr '99	RIP, RIP2, VRRP, OSPF	DHCP relay agent, others planned	Fax support today, modem relay 2Q00

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TABLE 3 IAD Data Features

Merlot Communications	Magnum ASP/ Nov '99	OSPF, RIP1&2, BGP4	VPN via ATM PVCs, SPVCs & SVCs (firewall, NAT and DHCP planned)	Preassigned ports, fax and modem pools
Nortel Networks	Passport 4400 family/ since '97	OSPF, RIP1, RIP2, L2 bridging (Eth and TR) SNA via RFC 1490	DHCP, FTP, HTTP, NAT and VPN (SKIP & IPSec) server functions	Group 3 via V.17, 22, 22bis, 27 and 29
Nortel Networks	Passport 5430/ Feb '00	OSPF, RIP1, RIP2, BGP4	Hardware-based data compression	Via V.17, 22, 22bis, 27,29
Premisys Communications	IMACS family/ current	OSPF, RIP1, RIP2, FR, PPP	DHCP, NAT and L2TP, VPN (IPSec) and advanced packet filter	Via fax relay
Premisys Communications	StreamLine/ current	OSPF, RIP, FR, PPP	None	Transparent
Premisys Communications	SlimLine/ current	None	None	Transparent
RAD Data Communications	FCD-IP/ current	Static, RIP1, RIP2, SIP/ SAP, RFC 1490, L2 bridging	None	Via PCM
Siepens Info & Comm Networks, Inc.	InterXpress IAD 4700/ current	Static, RFC 1483, L2 bridging	DHCP and NAT, firewall	Compressed or with Q.SIG or DSS1
Sumoma Systems	Access & Integrator/ current	Static, L2 bridging	None	Future
Telco Systems	EdgeLink 300 T1/ E1 Dec '98	Static, RIP1, RFC 1490	DHCP and NAT, IP filter	Via POTS (G.711) or G.730
Vina Technologies	Multiservice Xchange (MX)/ YE '99	Static, OSPF, RIP1, RIP2	DHCP, DNS, IP packet filter & QOS NAT, SOCKS	Via TDM and DS0/ FSX
Woodwind Communications	ClariNet Service Intelligent Network Edge Gateway/ Feb '00	RIP1, RIP2, RFC 1483	DHCP & NAT	Via V.34 over PCM